

Module : Advance Industry 4.0 [ACPA7000]

Assignment - Essay

"Manufacturing Systems Emerging Technologies"

Course : MSc Industry 4.0 Advanced Manufacturing

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1. Summary / Overview

The below piece of work shows the investigation of current manufacturing systems which are commonly used in day-to-day activities & make things easy for the industry. This technology has been identified in possible areas where it can be utilized and works effectively in terms of human and environmental implications. This plays an important role in economic development. Further its also analysis each system individually with advantages and disadvantages as per industry 4 requirements followed by a conclusion which states if any social or economic benefits.

2. Introduction

Industry 4.0 is the main phase of the revolution in the industry. The main root of this is manufacturing but it seems that it has grown increasingly across all sectors. The implementation of the new systems it's also known as smart manufacturing, digital manufacturing, and digital transformation. It's related to the business environment where machines can bridge digital worlds, and collects and analyze real-time information. The core components of industry 4.0 do not depend on the tool or technology. It is developed on digital innovations from recent decades. following are the pillars of the industry that plays a key role in the society (Sharma A, 2020)

In 2013,if we have a look on the market for additive manufacturing, the product market had grown worldwide to \$3.07 billion showing the compound annual growth rate (CAGR) of 34.9%; as per the expert report the size of AM will be at \$10.8 billion in nearer future (Wholer and Caffrey 2013).

This essay will investigate the impact of these technologies on product creation, the future role of the resources working in manufacturing companies & implications for our society and our environment. This piece of work will begin by presenting the most viable manufacturing systems are the main product of their processes, Individual companies had made choices of which technologies should they adopt to grow their business with the minimum defect. This essay gives s theoretical approach to looking at Business 4.0 as the fourth generation.

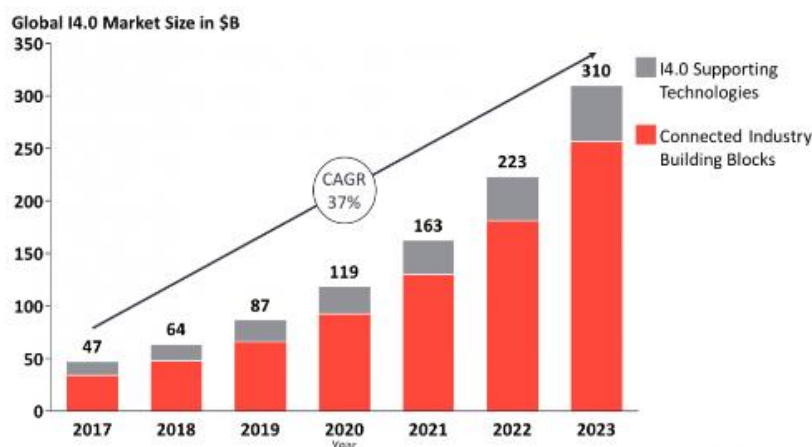


Fig 1 : Global Industry 4.0 Market size 2017-2023

3. Current Manufacturing Systems

Smart manufacturing is the category that employs computer-integrated manufacturing, rapid design change, digital information technology, and more flexible workforce training. In this concept, a smart factory has interoperable systems which include automation and networked sensor. this covers various technologies as listed below and expands with information about their possible places of utilization & impact on social/environmental areas.

- Additive Manufacturing (3D printing)
- Virtual , augmented and mixed reality.
- Digital twin and simulation.
- Cyber security
- The industrial Internet of thing (IIOT)
- Cloud computing
- Block chain
- Data science

The below image shows a diagrammatic representation of various manufacturing systems in smart factories which result in fast production rates & fulfill the customer requirement with zero defects.

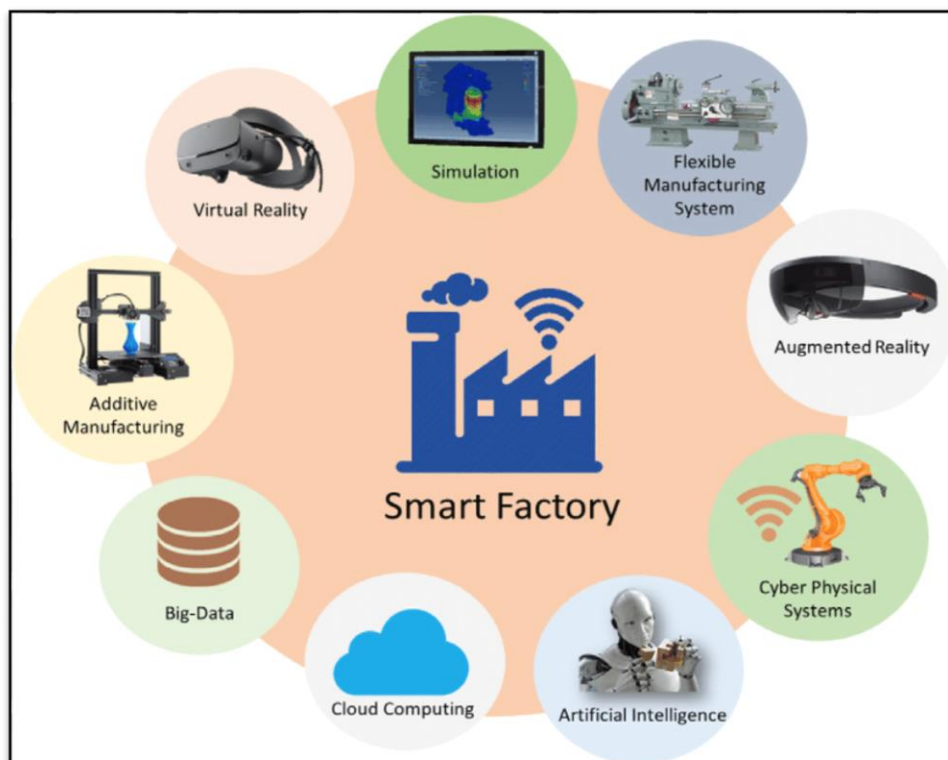


Fig 2 : Smart factory - Manufacturing system

4. Emerging Technologies and its adaptation

Below listed technologies explain in detail their implication in industry 4. These are the main fundamental through which digital transformation is driven. In the below section, the main digital technologies through which the industry vision is empowered are explained, and their importance for future factories is highlighted.(John S, 2018).

4.1. Additive Manufacturing

Additive manufacturing is the process which is also known as 3D printing. This technology uses 3D models to create the part. From many tears, this is used for making prototyping. recently due to the greater affordability of digital scanners and printers had grown this process into a very valuable technology system across all industries. easy for rapid prototyping and mass customization allowing the complex design to make it significantly less time and minimum cost. AM technology has been since 1980 & importance changed drastically over the last 5 - 10 years as shown in figure 2 below.

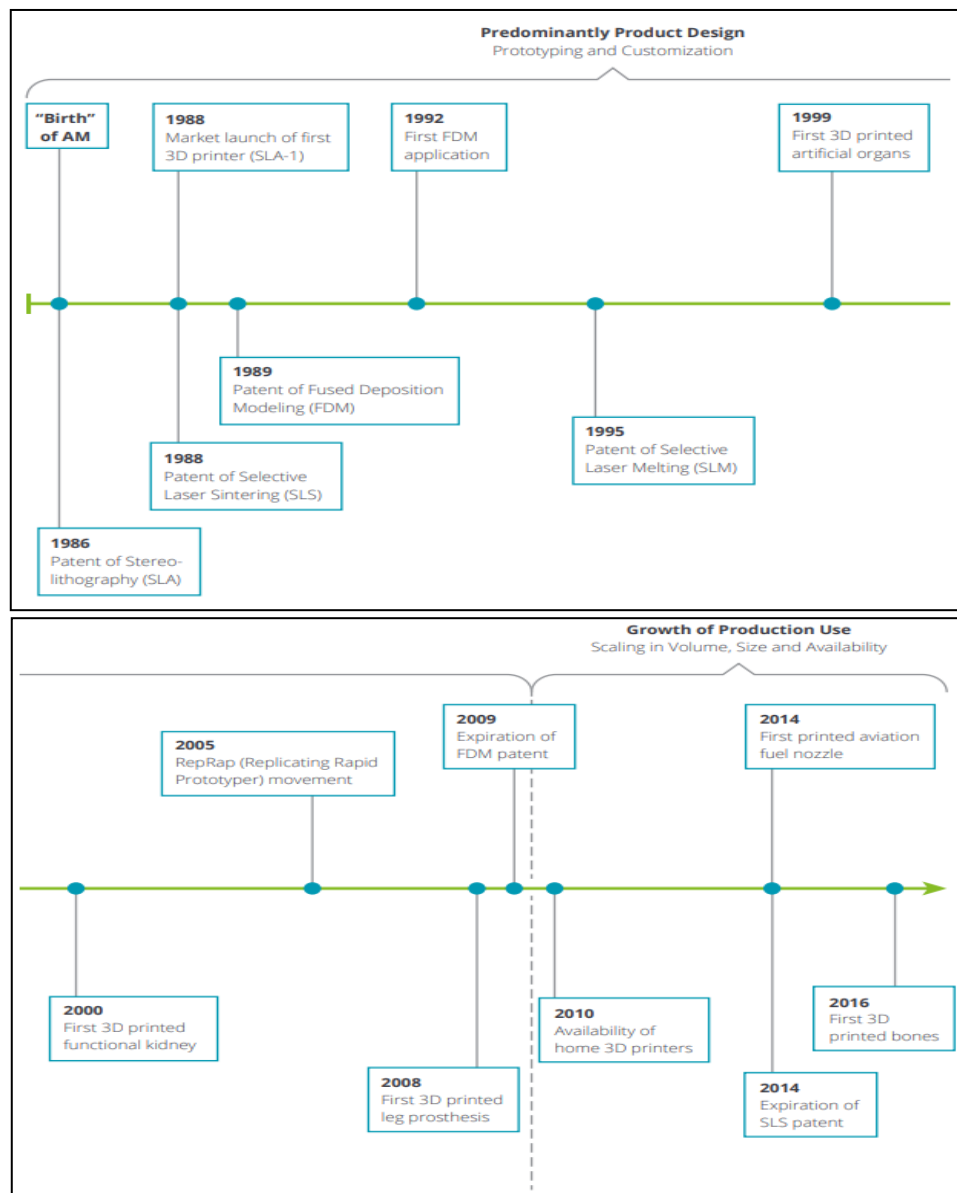


Fig 3 : Development and milestones of Additive Manufacturing

Additive manufacturing is widely used in aircraft industry. SAFRAN has already implemented 3D printing parts in their seating system. which results in controlling the project cost and component manufacturing time. Apart from seating, there are many areas where this technology can be applied. Safran France has a 12500 sq ft meter facility to make the parts with AM process. This process delivers real benefits to aviation as eco friendly process while significantly reducing weight and contributing to decarburization (Safran,2022).

Possible areas of utilization of AM are various sectors like Medical, construction, Manufacturing industry. energy, and consumer products. It shows potential to decrease environmental impact.

Additive manufacturing problems/disadvantages include High power consumption, time-consuming comparatively slow process, and limitations regarding what material and sizes to be print (Gutowski et al., 2017).

Below images shows the aircraft areas (like ; Component connector, Ducting, Baggage compartment, Air filter boxes, seating system etc) were additive manufacturing parts are implemented.

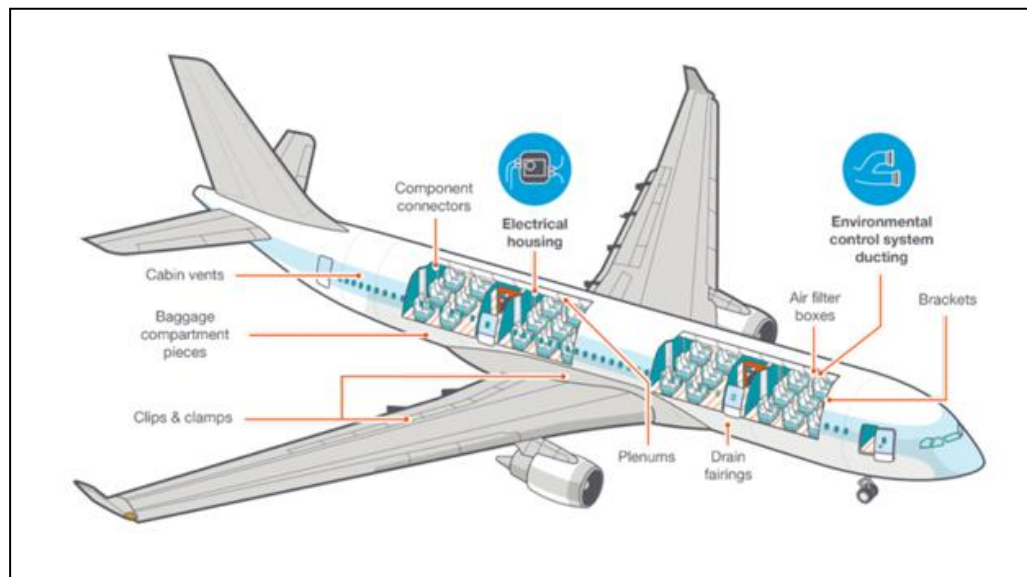


Fig 4 : Additive manufacturing in Aerospace

4.2. Virtual, Augmented and Mixed Reality

The basic concept of this each technologies as follows,

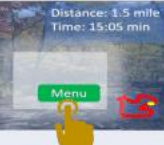
		Extended Reality (XR)		
	Reality	Augmented Reality (AR)	Mixed Reality (MR)	Virtual Reality (VR)
Display	Naked eye/optical glasses	Translucent display	Translucent display	Occlusion display
Display example				
Example	 Real view of a trail	 Augmented virtual map and direction	 Interactive virtual contents	 Virtual gaming

Fig 5 : Virtual, Augmented and Mixed Reality

Augmented reality (AR) gives us an overview of the real world by overlaying the things that we see with computer-generated information. Nowadays this technology is observed in smart phones. By just taking the picture from the camera and due to real-time processing, the app can display contextual information or gaming and social experiences that seem to be founded in the real environment.

Virtual reality (VR), which can be referred to as computer-simulated reality, replicates an environment that simulates a physical presence in places in the real world or an imaginary world allowing the user to feel and interact within that environment.

Mixed reality (MR) is a mixture of physical and digital worlds. This new reality is based on advancements in computer vision, graphical processing, display technologies, input systems, and cloud computing. The essential elements for creating mixed reality experiences are Computer processing with cloud, Advance inputs method, and Environmental perceptions (John S, 2018).

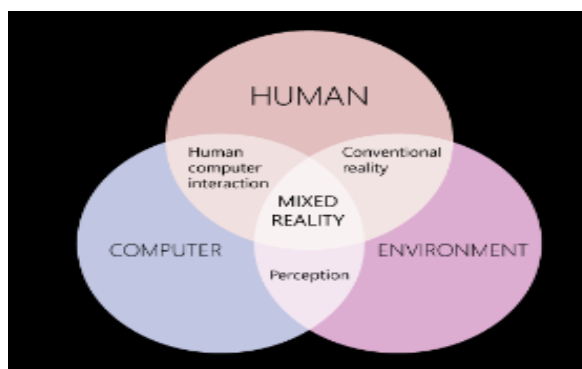


Fig 6 : Mixed Reality Structure

Recently in the year 2021, the launch of specific glasses models have been introduced in the market form, Lenovo Think Reality A3, and Vuzix's Next Gen Smart Glass. This will play an important role in this digital world to experience the real feel of this technology. The devices which are used are Holographic devices and Immersive VR devices that display the digital object as if they existed in the real world.

Possible areas of utilization are Education which provides revolutionizing learning and makes it more immersive. observed that many universities had implemented courses in their syllabus. The manufacturing industry very much benefits from these technologies as they can assist new workers through AR gadgets & MR facilities by providing them with holographic instruction right before their eyes. The implication of these technologies in the environment is due to poor IT equipment may lead to producing electronic waste. The more VR devices are developed, the greater footprint of the environment will be left behind.

Problems that may be encountered in this technology are Technical issues that may affect the learning activity & may include hardware issues / Content Glitches / User difficulties. These issues can be resolved by running a pilot program with a select learner group so that the organization can concentrate to create solutions before the wide rollout (Naveen J, 2019).

4.3. Digital Twins and simulation

The digital twin is the representation of an actual physical asset which are in operation and includes relevant historical data. The digital twin can be a component, a system of components, or a system of systems. Also, industrial processes are generally inflexible and practically impossible to cancel or undo the action. Here digital simulation plays an important role with the help of digital data we can analyze the effect in the real world without testing all scenarios in the field. (Lets learn Aviation, 2019).

The figure represents the general idea behind the physical asset of digital twins by considering a number of factors as well.

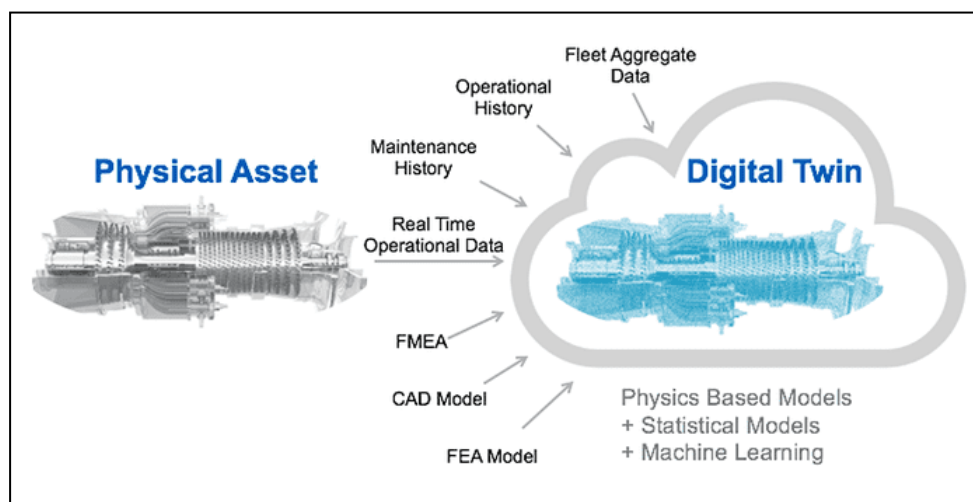


Fig 7 : Digital Twin in Industry

The digital twin has impacted the industry in better research and development of products and the use of liberal data for estimating performance outcomes. The technology helps to initiate refinements before the actual process. The utilization of this process is captured in the picture below.

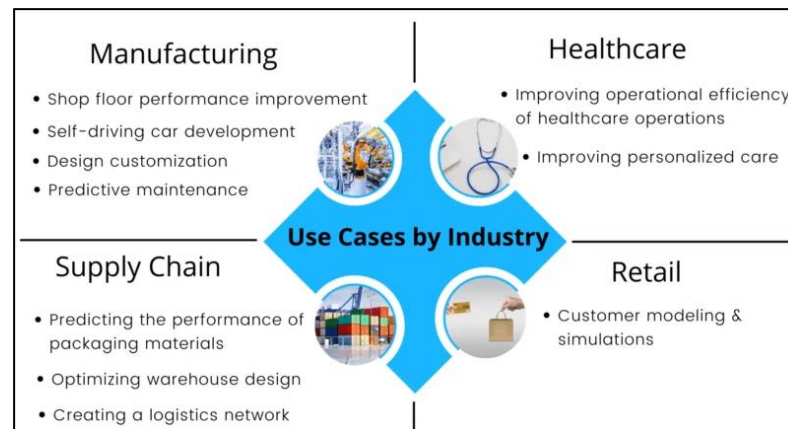


Table 1 : Digital Twin utilization in Industry

In terms of environmental implications this technology is used to reduce the carbon footprint. This digital twin gets data and insights into key things to improve this product. With these technologies engineers can estimate how much cost is involved to purchase, operate and fix the system. A digital twin is utilized in aerospace companies. According to the article (Impact, 2022), Boeing company saw a 40% improvement in the quality of parts by using digital twin in development. These new parts are able to simulate their performance in different conditions eg . engine fair in harsh weather. The implementation in aerospace brings new possibilities like tracking performance in action.

Problems that may be encountered is the risk of misrepresenting the object or system that we want to replicate. Considering the fact that limited information about the accuracy of the twin compares to its physical counterpart. Therefore, to solve this problem, the physical object required to open and inside the potion must be represented manually using animation and code. In most cases, manual revisions are performed to ensure the accuracy of the simulation. Below image about its architecture.

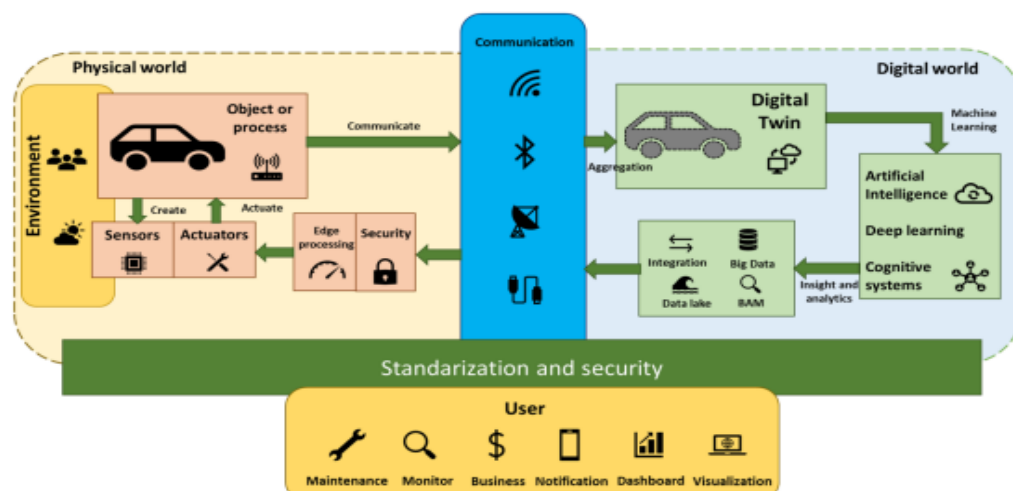


Fig 8 : Digital Twin Architecture

4. Cyber Security

Cyber security terms can be defined as the protection offered through online services to secure our data. Due to the increasing amount of internet users a massive increase in cyber attacks. This security is useful for securing data from threats like data theft & our system gets safeguarded from viruses.

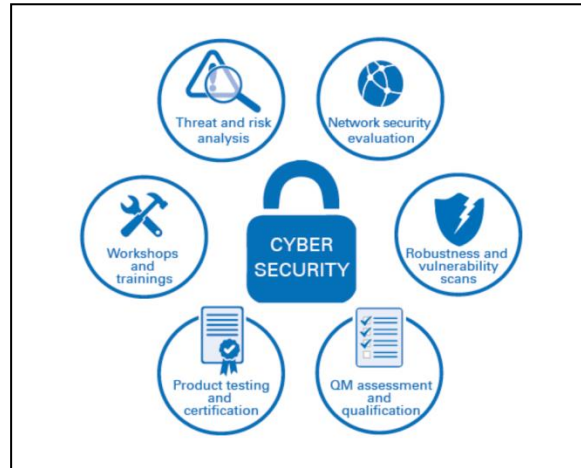


Fig 9 : Cyber security in industrial Automation

The below image describes the nature of leaps to date for better understating. Its seen that the risk to manufacturing has existed until the production has been mechanized. Connected production creates new cyber challenges (Mark C, 2016).

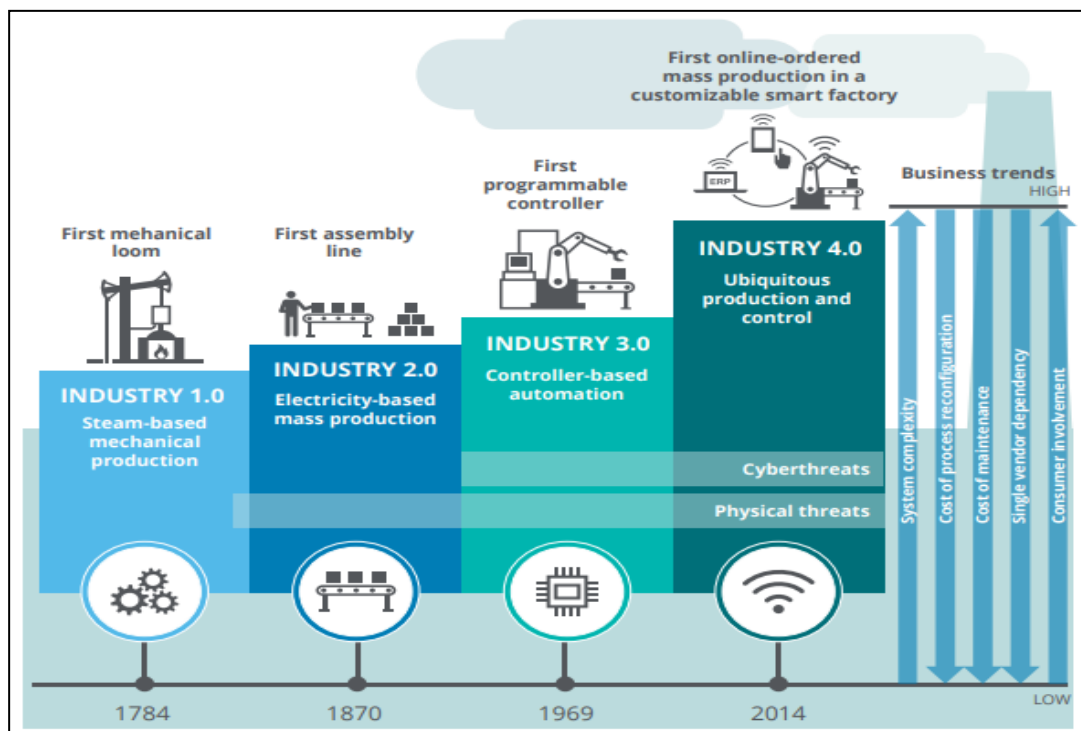


Fig 10 : Cyber and physical threats in each industrial revolution

There are many techniques and attacks in cyber security that exploit the humanistic aspect for example : Social engineering, Business Email Compromise and Human error. This all can be reduced by following points.

- Educate the employee by spreading knowledge and awareness._
- Implement a security policy.
- Ensure access management.

Problems that may be encountered and their solutions are explained below (Leandros M, 2021).

Viruses and Worms : Program was installed into our system due to a lack of knowledge. A specific security suite should be incorporated within the computer against threats. various suite available in market such as: VIPRE, McAfree, AVG, Norton, F-Secure, Security Essentials & Quick Heal ect.

Hackers : Its mainly who breaks the security wall and gain access to administrative controls. The different type are White Hat, Grey Hat & Black Hat Hackers. This can be control by keeping the strong password and usage of firewall.

Malware : It's any software that infects and causes an issue in the system without the owner's permission. To stop this download anti-Malvern software, and activate the firewall and antivirus.

Trojan Horses : These are email virus that duplicates them self and corrupt the computer. To overcome this security suits like Avast internet security should be installed.

The below images shows the top emerging cyber security threats for upcoming year.



Fig 11 : Cyber security Threats for 2030

4.5. The Industrial Internet of things (IIOT)

The Internet of things (IoT) can be defined as a system of interrelated or connected objects through the internet which can collect and transfer data over the wireless channel with any human effort. IoT describes the network of physical objects or "things" which are incorporated with sensors, different software, and other technologies for the purpose of connecting and exchanging data with different devices which are connected with the system through the internet. The concept represented in below image for reference.

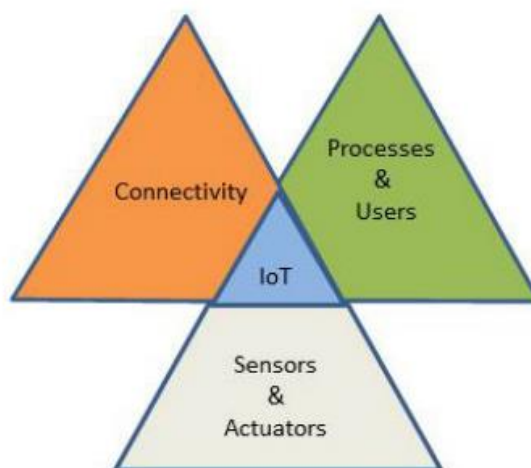


Fig 12: The IIoT Concept

The architecture of IoT systems can be divided into four layers: Object sensing layer, data exchange layer, information integration layer, and application service layer. The short list of application where they are mainly used are as follows below,

- Connected intelligent buildings.
- Smart cities and transportation.
- Education system.
- Consumer electronics.
- Agriculture and environment.
- Manufacturing & many others.

The enabling technology like Power and energy storage technologies is developing in the field of energy generation and harvesting solutions. Sensors are the key building blocks of the Internet of Things. sensors can also implant under the skin with min size and can be detected a hundred miles away. The important thing about IoT is data storage which is controlled by the technology of cloud computing and can handle a huge amount of data as backup.

In terms of challenges, Many challenging issues still need to be addressed. The main challenges faced in the development and deployment phases of the IoT are : Reliability, Interoperability and Security and Privacy.

In terms of Barriers, they are especially in the field of regulations & security which are mainly Absence of Governance ,& Privacy with Security (Jordi S, 2017).

The working pressure follows collecting the data further sending data to cloud connectivity to process the data and then to the user interface by delivering the information to the user. The below figure shows data analytic w.r.t industrial and consumer.

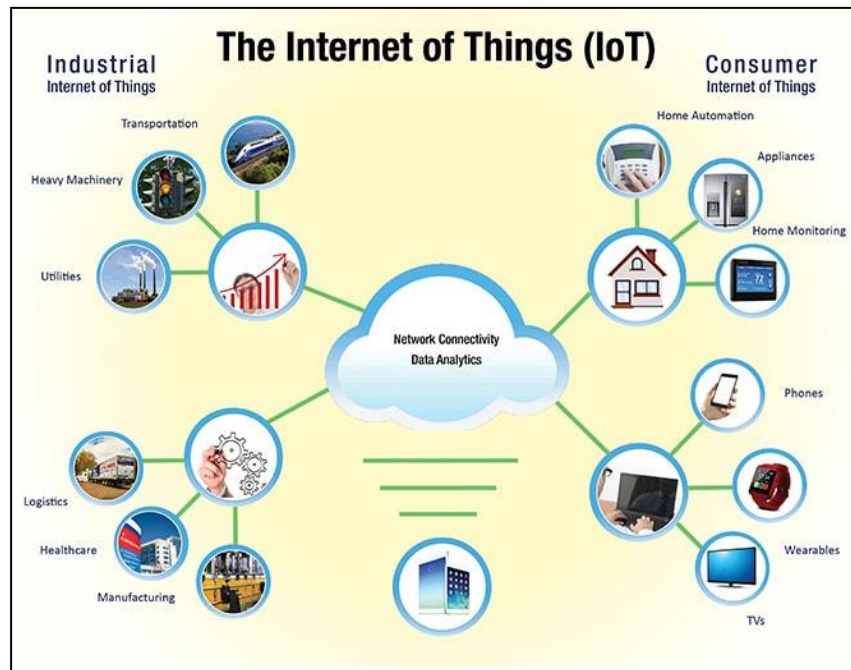


Fig 13: IoT connectivity Data Analytic

In terms of humanistic or environmental implications, the effecting factors are the first one its small size which means the physical production of specific material thus producing less E-waste. The second one is the software used in the devices as it has memory restrictions. The special software option to create IoT is known as an embedded system. This helps the environment to go green & reduce energy consumption through optimization. The problems that may be encountered with IOT are as follows.

Incorrect Access control: It should be only accessible by the owner & the trusted network when it's connected to the internet. The common problem is that the series of devices are delivered with the common password with the default setting. This should be changed by the user if unchanged then as public knowledge, this device series continues with the default setting which can be accessible by another user.

Overlay large attack surface: If more services a device offers then more services can be attacked which is known as an attack surface. The unnecessary services should be prevented by not exposing them.

Outdated software: The IoT device must be up to date. In general, all IoT devices should be upgraded with the latest software to avoid this problem.

Lack of encryption : Sensitive data which is stored on a device (at rest) should also be protected by encryption. The common problem in this section is using plain text version of protocol.

Application Vulnerabilities : Constantly validation of the input should be performed to avoid application vulnerabilities.

Insufficient privacy protection : Consent of the end user of the device should be considered.

6. Cloud Computing

In cloud computing, the system uses the internet to disturb resources, software, and information on demand to computers and other devices. The term cloud refers to a network or internet which is at a remote location and can provide services over the network. Cloud computing provides information as a service from digitized systems. Internet cloud services require no prior knowledge of resource management to use.

The history of cloud computing is that this concept developed from telecommunication companies changing VPM. In 1999 salesforce.com started delivering applications via the web. In 2002 Amazon elastic compute cloud (EC2), Eucalyptus in 2008 & Microsoft Azur in 2009.

Cloud architecture, the system architecture of the software system involves multiple cloud computing communication with each other over application programming interfaces, usually web services. The component of the cloud computing are mainly known as the front end and the back end. The front end of the part seen by the client (ie. computer user).The back end of the cloud computing architecture is the "cloud" itself, comprising various computers, servers, and data storage devices. Types of cloud computing are Public cloud, Private cloud & Hybrid cloud. (John S, 2018).

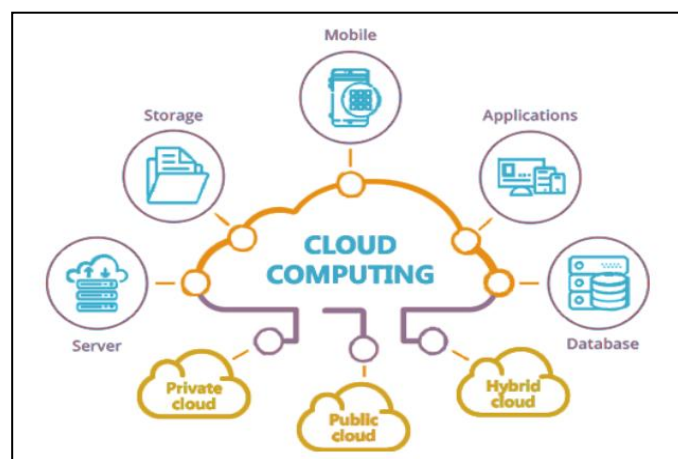


Fig 14: Cloud Computing in Industry

The public cloud can be accessed by the general public by the service provider of cloud infrastructure. a cloud provider like Amazon AWS, Microsoft, or Google has the authority to run the cloud infrastructure. The customer has no idea or control over where this infrastructure is located. The same infrastructure is shared by customers on the public cloud.

A private cloud is an infrastructure that is dedicated to a specific company. This cloud allows businesses to host applications while addressing concerns about security. It is not shared with the other organization, it can be hosted internally or externally.

The Hybrid cloud is the combination of two or more two clouds (Private, community, or public) In hybrid cloud flexibility of computing is seen as it provides leverage to a third-party provider.

Possible areas of utilization/application involve the following.

- Online data storage
- Backup and recovery
- Big data analysis
- Testing and development
- Antivirus application
- E-commerce application.
- Cloud Computing in Education

In terms of humanistic or environmental implications such as it is reducing energy consumption, It has been seen in the report that if businesses transfer their everyday work application to this environment then it would reduce global IT energy use by 87% and has the potential to prevent around 1 billion tons of Co2 emissions in upcoming reads.

Problems that may be encountered are related to maintenance, storage, and security. The resource required to manage and maintain this digital data which leads to more cost. Its difficult to migrate between CSPs, user finds difficult to switch for better service provider.

The solution to all these issues came in form of cloud computing and cloud security. With this, the information can be safeguarded at a remote location rather than used on the local computer. This data can be accessed from any were on the internet.

The importance of cloud computing is highlighted in the image below for reference.



Fig 15: Importance of Cloud Computing in Industry

4.7. Block Chain

Block chain technologies provide the potential to upend the way every industry manages its information and data and financial services. Examples are Legal, supply chain, Government, Energy, Food, Retail, Healthcare, Insurance, Travel Hospitality & Education sectors as shown below the table for reference.



Table 2 :Block Chain for Every Industry

Design principles of block chain technology

The principles for shaping the next era of the digital economy, and an era of renewed trust are as follows (Don T, 2016).

1. Networked Integrity : Integrity is encoded in every step of the process and distributed, not vested in any single member Participants can exchange value directly with the expectation that the other party will act with integrity. The implications it's about any endeavor that requires trusted records and assured transactions. who ? and What? should b considered.
2. Distributed Power: The principle states that everyone can see what's happening if half of the network attempts to overwhelm the whole. The system will have a single point of control. No single party can shut the system down. Implications lead to new distributed models of wealth creation.
3. Value as Incentive: The Principles about the stakeholder to provide them an incentive. Token or Bit coin rewarded to those who worked on it , ultimately means the block chain is distributed globally. Implications are proper financial incentives to collaborate effectively.
4. Security: The Principle states safety measures considered and no single failure and provides confidentiality. Anyone who wants to participate must use cryptography with no opting-out option. Implications are more secure design and transparency in what we do to our data.
5. Privacy: The Principle states that people should be able to control their own data and have the right to decide their share. Implications to be sure, the block chain provides opportunities to stop the stampede of a surveillance society.
6. Rights Preserved: The principle states the transparent ownership and individual freedoms to perform. Implications for the Block chain Economy as enforcing rights must start with clarifying rights.
7. Inclusion Principle: A platform for distributed capitalism as the economy works best when it's for everyone. Implications as the foundation for prosperity is inclusion and this can help.

Benefits of the Block chain are listed as below,

- Budget (Reduce cost in transactions).
- Globalization (worldwide irrespective of location).
- Security (Improve security and efficiency).
- Irreversibility (Transaction cannot be reversed).
- Velocity (confirmation within minutes).
- Anonymity (Bit coin is not connected to real-world).

The development of a less energy-intensive alternative due to this technology with lower transaction costs, and high-security protocols would render the block chain ideal for sustainability paradigms in the economic, environmental, and social sectors.

Problems that may be encountered with these technologies are as follows.

- Block chain has an environmental cost.
- Lack of regulation creates a risky environment.
- Its complexity means end users may find it difficult to get its benefits.
- Block chain can be slow.
- The establishments of great interest may lead to failure.

4.8. Data Science

The term Data science is a new term but it can be defined as a multidisciplinary field that uses scientific methods, processes, algorithms, and systems to capture knowledge and insight into data whether it's structured or unstructured. It employs techniques and the theory investigated in many fields like to mathematics, statistics, and computer science. It is the fourth paradigm of science.

- Thousands of years - Empirical
- Few hundred years - Theoretical.
- Last fifty years - Computational / "Query the world".
- Last Twenty years - e Science (Data Science) / "Download the world".



Fig 16 : Data science system

- An application and the possible areas of utilization that is built upon data science exploring the various domain as listed below.
 - Internet Search
 - Fraud and Risk Detection
 - Healthcare
 - Targeted Advertising
 - Website Recommendations
 - Advanced Image Recognition
 - Speech Recognition
 - Airline Route Planning
 - Gaming
 - Augmented Reality

Impact of Data science on the society are,

Saving energy: This system definitely helps in saving energy as everything is handled digitally.

Simplifies Tedious Tasks: Repetitive work is reduced and tricky tasks are adapted by people.

Public Health and Welfare: Before releasing any data to the public, scientists, and doctors must evaluate the data about its possible advantage to avoid any problems.

In terms of the humanistic or environmental implications of such adoptions, insights can bring significant benefits to the organization and the businesses to grow and analyze. This analysis can predict the business growth and correct marketing requirement to correct people. Data analysis can give us an idea about the percentage of people interested or not in a specific industry or product. this will help the society to develop and share their thoughts as a review. In terms of production company we can analyze the material requirement and less scrap will consume less of the planet's raw materials which will lead to less Co2 footprint.

Problems that may be encountered with data science may include

Not Enough Data: If the data is limited it's difficult to create algorithms and output. we can increase the data by randomly generating the values or by Data augmentation & avoid Over fitting.

Too Much Data: There is a problem when min data but also if we have too much data, having more data does not guarantee your accurate output. Using fewer and specific data factors such as computational power, time taken and the overall output will allow more accurate output (Xiong Y, 2015)

5. Conclusion

5.1 Impact Interconnected

With reference to the above essay, there are many technologies that are interconnected to each other and the effectiveness is observed when they are adopted together or when they are used in combination with each other. Machine learning feeds off big data. Big data is created by the sensors and connected machines in the physical layer. Further without this linked with the cyber, IIoT would be a simple thing only like the Internet. The IIoT will work due to connection with networks & this network device is connected to the cloud. The physical environment is captured and then only the AR will work. The same simulation tools and the digital twins are interconnected.

5.2 Customer requirement

From an environmental perspective, the important factor to implement all technologies is the key benefits of each system and the specialty involved with them to do the allocated task in time and perfection. the flexibility of this system plays a key role when they are combined together. This leads to completing the task in min time. In line with the production company, the manufacturer can analyze the time study and react to customer demands accordingly which may lead to more products and reduce the volume of mass- products.

Mass customization is in the manufacturing system which gives customers what they want at an affordable price. As the smart manufacturing system is adopted by many manufacturing companies the environmental damage due to another system will be reduced. Also, the consumer trends with a high circulation of policy with sustainability and development will determine the manufacturer's goods.

5.3 People role implication

This technology may lead to reduce in manpower & also generate specific jobs with the required skills. The job location may be at different locations. I the previous industrial revolution many cities were developed with new opportunities. For example, due to modern automation, human efforts are taken place by robots but traditionally, humans are required to carry out maths and analyze the data.

Predictions for the fourth industrial revolution will be a skilled job with the latest technology get high pay as compared to the low-skill segment. The requirement by the organization will be developing new skills and the ability to learn new processes. The role may get varied after implementing a combination of technologies irrespective of the domain experience.

5.4 Society and environment implication

The role of Industry 4.0 in society and its environmental implications is significant. The manufacturing product is made with resource efficiency. Optimized manufacturing can be achieved with data analytics and AI. Technology like additive manufacturing reduces material waste and the circular economy of the product is achieved by block chain technologies. The manufacturer can solve their problem on its own and a sustainable platform is achieved.

References:

1. Sharma, A (2020), " *Evolution of Industrial Revolutions: A Review*". International Journal of Innovative Technology and Exploring Engineering. 9. 66-73. DOI : 10.35940/ijitee.I7144.0991120.
2. Wohler T, Caffrey T (2013)," *Wohlers report 2013: Additive manufacturing and 3D printing state of the industry*". Annual worldwide progress report. Wohler's, Fort Collins
3. Safran (2022), "Safran inaugurates the safran additive Manufacturing Campus , a new center of excellence". Available at : <https://www.safran-group.com/pressroom>. (Accessed : 02 Feb 2022).
4. T. Gutowski,et al (2017), "Note on the rate and energy efficiency limits for additive manufacturing" J. Ind. Ecol., 21 (S1) (2017), pp. S69-S79 DOI : <https://doi.org/10.1111/jiec.12664>.
5. John S (2018), "The Digital Shopfloor- Industrial Automation in the Industry 4.0 Era",[Online], USA, Available at : <https://library.oapen.org/handle/20.500.12657/59751>. (Accessed : 02 Feb 2023).
6. Naveen Joshi (2019), " *Challenges with augmented reality*". Allerin 22 Aug 2019, Available at : <https://www.allerin.com/blog>. (Accessed : 04 Jan 2023).
7. Lets learn Aviation (2019), "Digital Twin in Aviation", Available at : <https://www.youtube.com/watch?v=gE0Z-lQdMtI>. (Accessed : 28 Jan 2023).
8. Impact (2022), " *Digital Twins in Aerospace*", Available at : <https://www.impactmybiz.com/blog/digital-twins-in-aerospace> (Accessed : 31 Jan 2023).
9. Mauricio A, (2022), "Digital Twin Technology Challenges and Applications: A Comprehensive Review. Remote Sensing. 14. 1335. 10.3390/rs14061335.
10. Leandros M, (2021)," *Cyber Issues in Emerging Technologies*" [Online], (1st ed.). CRC Press. <https://doi.org/10.1201/9781003109952>. (Accessed : 20 Jan 2023)
11. Mark C, (2016)," *Industry 4.0 and manufacturing ecosystems: Exploring the world of connected enterprises*", Deloitte University Press, Available at : <https://dupress.deloitte.com/content/dupress/dup-us-en/focus/industry-4-0/manufacturingecosystems-exploring-world-connected-enterprises.html>.
12. Jordi S, (2017)," *Internet of things*", 1st Edition, ISBN 978-80-01-06232-6. Available at : <https://core.ac.uk/download/pdf/132530214.pdf>. Prague. (Accessed : 31 Jan 2023)
13. Don T, (2016), "Block Chain Revolution" Edition 1st, Penguin supports, New York, ISBN: 9781101980156 (eBook) , Available at : https://itig-iraq.iq/wp-content/uploads/2019/05/Blockchain_Revolution.pdf.
14. Xiong Y (2015), " *Towards Data Science*". Data Science Journal, 14, p.8. DOI : <http://doi.org/10.5334/dsj-2015-008>.